Evaluation of the Analysis Influence on Transport in Reanalysis Regional Water Cycles

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1. Motivation

Evaluating MERRA and Interim global and regional water cycles, Trenberth et al. (2011) show long term average moisture divergence over the central United States. What part of the observing system and analysis influence this?

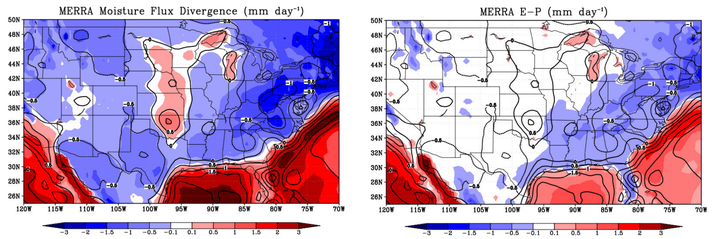

Figure 1 MERRA moisture flux divergence (left) and E-P (right) compared to the analysis increment of water vapor (contour) for the period 2002-2008 following Trenberth et al. (2011). Units mm day^{-1}

2. Budget Terms

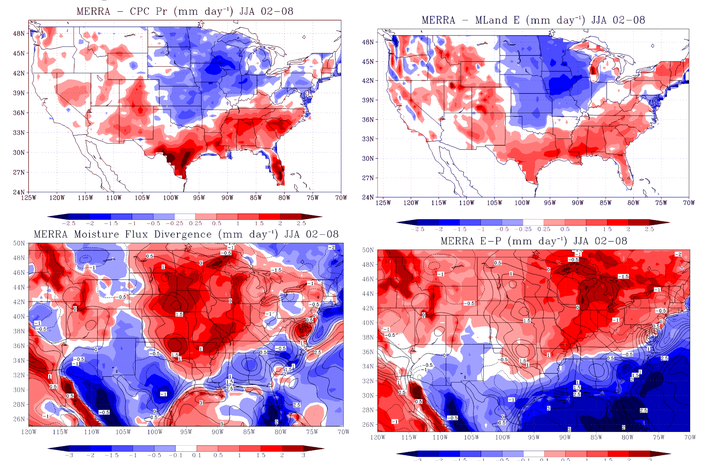

Figure 2 JJA 02-08 budget terms from MERRA for precipitation departure from gauge observations (upper left), evaporation anomaly compared to MERRA-Land reprocessing (upper right), Also, JJA moisture flux divergence (lower left) and JJA E-P. Units mm day^{-1}.

The noted moisture divergence anomaly and analysis increment are strongest during JJA. Also, there is a significant underestimate of precipitation and evaporation then. The increment source of water occurs upstream from the underestimates of P and E.

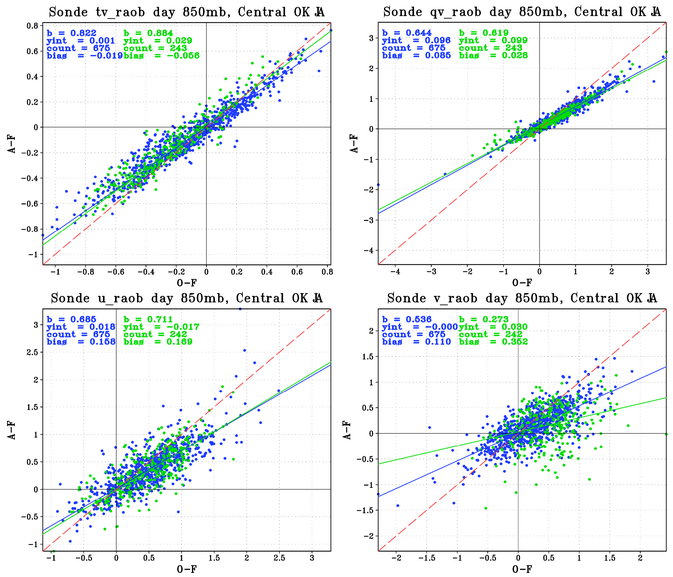

Figure 3 Monthly mean A-F and O-F during JJA for radiosonde observations in the central US (103W,-94W; 33N, 46N). For the period 1979-2009. Monthly means for JJA. The calculations are split between two periods (1979-2001, blue; 2002-2009 green). Solving the linear relationship above, the slope is the gain, or how much the analysis draws to that observation and Cb is the bias of the observing system.

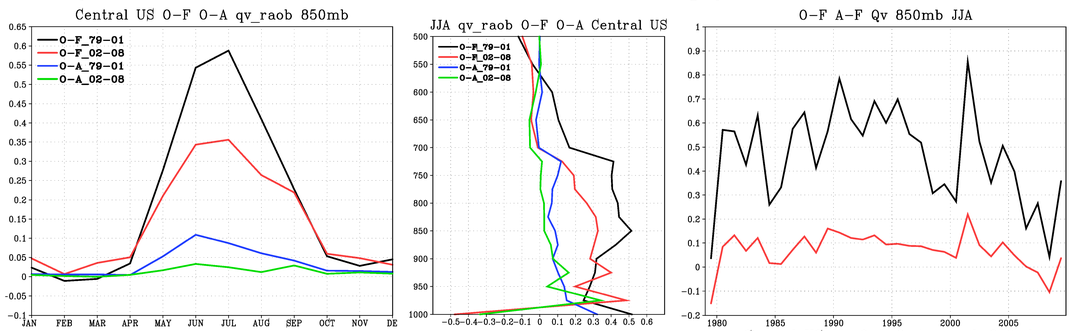

Figure 4 Central US area average O-F and O-A; mean annual cycle, JJA vertical profile and JJA average of water vapor (g kg^{-1}), and JJA average of V component wind (m s^{-1})

3. Forecast and Analysis Error in Qv and V

The MERRA GIO data provide innovation statistics from the analysis (e.g. O-F, O-A) as well as the observations. Figure 3 shows that the analysis of T, Q and U-component change little from 1979-2001 – 2002-2008. However, V component wind becomes less reliable in time (changing with the addition of LIDAR profilers and the inclusion of aircraft data, see also table 1). The water vapor analysis seems to improve in time.

Gridded Innovations and Observations (GIO)

The MERRA GIO collection of data includes the conventional and radiance observations that have been assimilated, and the forecast error (O-F) and analysis error (O-A). These provide useful statistics to evaluate the model and analysis (Rienecker et al. 2011). Here, we evaluate the JJA central US.

$$A\text{-}F = \kappa(O\text{-}F) + Cb$$

where Cb represents the bias of each observing system against the full observational analysis, and κ which represents the gain, or how much the analysis draws to the observation.

	Sonde				Profiler		Air Craft	
JJA 02-09	T	q	u	v	u	v	u	v
Cb	0.029	0.099	-0.017	0.03	0.123	0.102	0.209	0.077
K	0.88	0.62	0.71	0.27	0.52	0.46	0.35	0.27
N	243	243	242	242	659	659	486	486
	Sonde							
JJA 79-01	T	q	u	v				
Cb	0.001	0.096	0.018	0.0002				
K	0.82	0.64	0.69	0.53				
N	675	675	675	675				

Table 1 Contextual bias (Cb) and Gain (K) in the Central US conventional observations, before and after aircraft observations increase greatly.

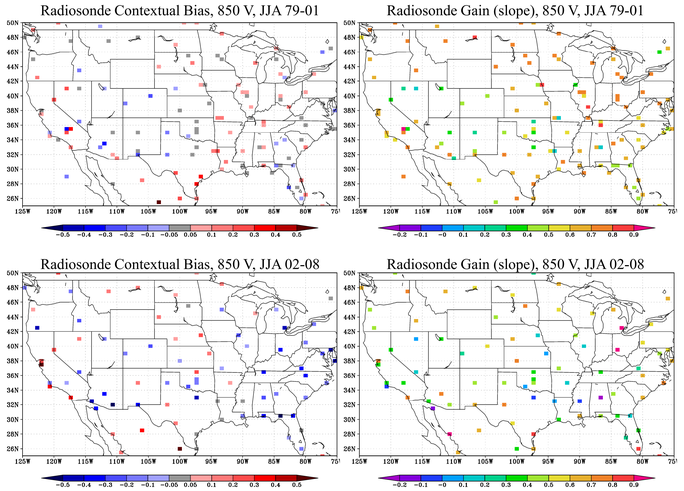

Figure 5 Spatial distribution of MERRA gridded sonde statistics showing that the V component wind bias of sondes increases during 02-08, compared to the previous record. Slope of the fit decreases in many places also, indicating the analysis is drawing less to this data.

4. Summary

The long term central US moisture divergence is generally related to JJA water increments. While moisture forecast error is decreasing in time, the meridional wind error increases for sondes as profilers and aircraft become more prevalent. Next Steps: Compute Moisture divergence from sonde obs.

6. References

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Rienecker, M. R. and co-authors, 2011: MERRA - NASA's Modern-Era Retrospective Analysis for Research and Applications. J. Climate, Vol. 24, Iss. 14, pp. 3624–3648.

Trenberth, Kevin E., John T. Fasullo, Jessica Mackaro, 2011: Atmospheric Moisture Transports from Ocean to Land and Global Energy Flows in Reanalyses. J. Climate, 24, 4907–4924. doi: 10.1175/2011JCLI4171.1

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